1. (a) What is the molecular geometry of CH$_3^+$? (Circle your answer.)

   trigonal planar    trigonal pyramidal

(b) Draw both molecular orbital diagrams to explain your answer to part (a). You may ignore the core electrons and only show the orbitals where the valence electrons reside plus the LUMO (you do not need to show the higher, unoccupied molecular orbitals). Please illustrate the MO’s as well as their relative energy levels. A Walsh diagram may be helpful.

(c) Now consider CH$_3^-$. Rationalize why it is trigonal pyramidal by comparing the appropriate molecular orbital diagrams.
2. (a) Using your “chemical intuition,” please name and draw the HOMO and LUMO for the following molecules. Please put your answer in the table below.
   i) CN\textsuperscript{−}  ii) H\textsubscript{2}C=NH\textsubscript{2}\textsuperscript{+}  iii) H\textsubscript{3}CBr

(b) Now, in the table below, construct molecular orbital diagrams for each of the molecules. Clearly label the HOMO and LUMO in each MO diagram. You may ignore the core electrons and only show the orbitals where the valence electrons reside plus the LUMO (you do not need to show the higher, unoccupied molecular orbitals). Please illustrate the MO’s as well as their relative energy levels.

<table>
<thead>
<tr>
<th>Molecule</th>
<th>Chemical Intuition: HOMO</th>
<th>Chemical Intuition: LUMO</th>
</tr>
</thead>
<tbody>
<tr>
<td>CN\textsuperscript{−}</td>
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<tr>
<td>Molecular Orbital Diagram</td>
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</tbody>
</table>
3. Using Huckel MO Theory, please illustrate why the cyclopentyl cation is unstable.
4. Construct a Hückel MO diagram for hexatriene. Label the frontier molecular orbitals. Draw the molecular orbitals. Determine the energy of each MO in terms of $\alpha$ and $\beta$. Determine the coefficients of the atomic orbitals in the frontier molecular orbitals.

\[ \text{Hückel MO diagram for hexatriene} \]

5. (Grossman, Ch 1) Explain each of the following observations.
   (a) Compound 1 has a much larger dipole moment than its isomer 2.
   \[ \text{1} \quad \text{2} \]
   (b) Imidazole (3) is considerably more basic than pyridine (4).
   \[ \text{3} \quad \text{4} \]
   (c) Fulvene (5) is electrophilic at the exocyclic C atom.
   \[ \text{5} \]
6. (Grossman, Ch 1) Please circle which of each pair of compounds is likely to be more acidic and explain why.

(a) 

(b) 

(c) 

(d) 

(e) 

(f)
7. (Grossman, Ch 1) For each of the atoms indicated with an arrow below, state whether the atom is nucleophilic, electrophilic, acidic, or none of these. For this problem, “acidic” means $pK_a \leq 25$. 

[Diagram of chemical structures with arrows pointing to atoms]